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# United States/United Kingdom Command and Control Study



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# UNITED STATES/UNITED KINGDOM COMMAND AND CONTROL STUDY

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# CHAPTER 1

# INTRODUCTION

**1-1. Purpose.** This report documents the conduct, methodology, and results of Phase II of the United States/United Kingdom (US/UK) collaborative command and control (C2) study. It includes recommendations on enhancing or developing performance models and combat effectiveness models at theater level. This effort was an attempt to expand the procedures and tools used in studies to more effectively represent C2 and the impacts of C2 on the battlefield.

**1-2. References.**

*a.* Defence Operational Analysis Establishment (DOAE). "Analysis of Alternative NATO C2 Structures Final Report - Phase I". Volumes 1, 2, and 3. Memorandum 92100. June 1992.

*b.* TRAC-OAC. "C3 Analysis Master Plan". Draft white paper. March 1992.

*c.* TRAC-OAC. "Command and Control Responsiveness Analysis (C2RA)". Volumes 1 and 2. Technical Report TRAC-TR-0591. December 1991.

*d.* TRAC-OAC. "Command and Control Measures, A Proposed Approach". White paper. June 1992.

*e.* TRAC-SWC. "Generic 1.0 Scenario". Scenario TRAC-SC-0592. May 1992.

**1-3. Background.** The US/UK collaborative effort began in March 1991 between the Training and Doctrine Command's (TRADOC) Analysis Command-Operations Analysis Center (TRAC-OAC) at Fort Leavenworth, Kansas, and the Defence Operational Analysis Centre (DOAC), West Byfleet, England. As more emphasis is being placed on C2, a better C2 representation in studies is required. Both organizations were eager to establish a methodology for analyzing C2 issues and to develop a tool to evaluate C2 systems. The theater-level perspective is especially important when analyzing C2 systems for their effect on the battlefield. In particular, the tools and methodology identified in this study would be very useful in analyzing the effectiveness of the combat service support control system (CSSCS), as well as other Army tactical command and control System (ATCCS) components since they are fielded at echelons above corps (EAC). Additionally, the evaluation of the standard Army tactical command and control system (STACCS) and the Army command and control system (ACCS) would be enhanced by using the methodology developed in this study.

*a.* This study is part of the C2 functional area model (C2FAM) ongoing in TRAC-OAC. C2FAM is an effort to develop performance models at division (the Division Command Post model (DIVCP)), corps (the command and control network model (C2NET)), and theater (the command and control performance allied North Atlantic Treaty Organization (NATO) theater, Europe model (C2PANTHRE)) levels with linkages to each of their respective level of combat

effectiveness model. C2FAM provides a capability to perform a qualitative and quantitative analysis of C2 systems and an inventory of analytic tools to support the analyses. The scope of C2FAM is shown in figure 1-1.

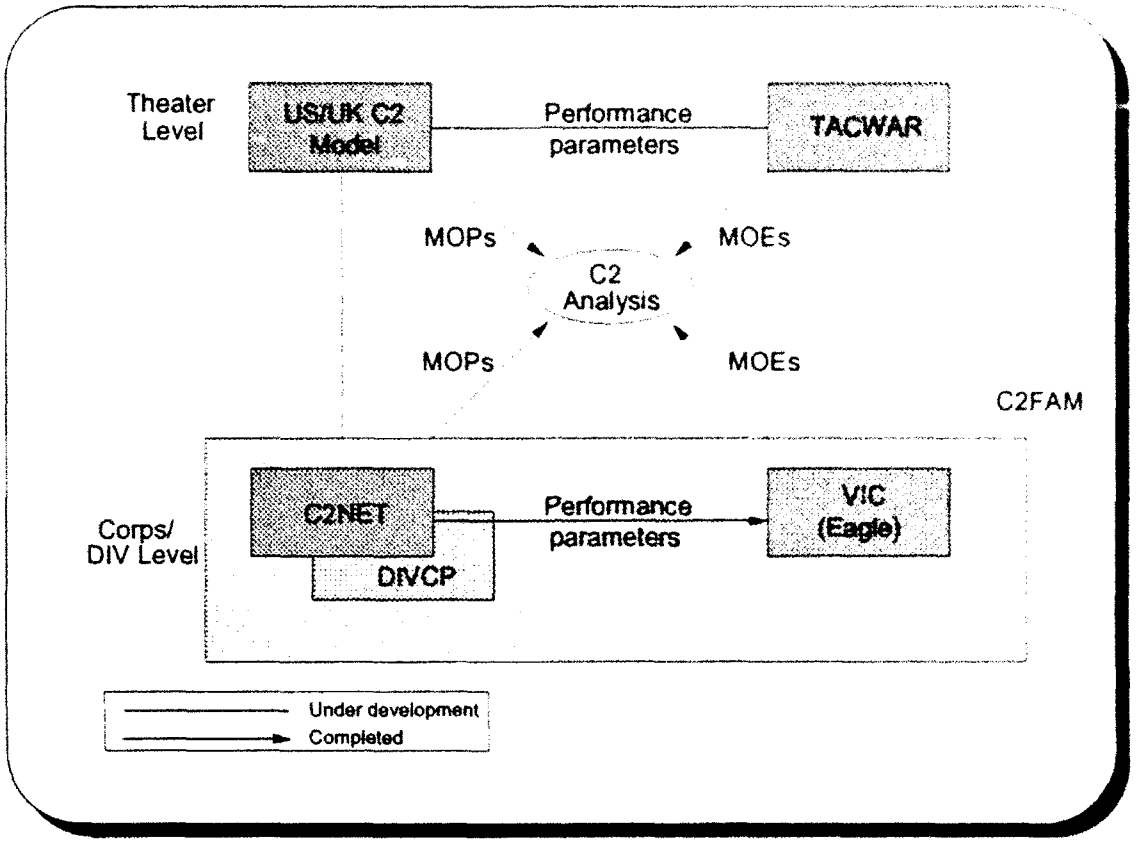


Figure 1-1. Extended C2FAM

*b.* This collaborative study was split into two phases. The focus of Phase I was to develop a theater-level performance model (C2PANTHRE) using the NATO's C2 structure from the Supreme Headquarters Allied Powers Europe (SHAPE) down to corps and the Combined Air Operations Centre (CAOC). Two alternatives were evaluated in Phase I for their performance characteristics using this model. The alternatives were the current (as of 1991) NATO European central region structure and a proposed post-conventional forces European (CFE) structure of the same region. Evaluating the two alternatives in C2PANTHRE yielded results which suggested staffing requirements for each C2 functional element at each echelon, time delays in translating SHAPE's intentions to orders for corps and CAOC, etc. This model and its results formed the basis for Phase II. For further detail on Phase I and C2PANTHRE, see reference a.

*c.* Phase II was established to complete the evaluation of C2 alternatives by linking C2PANTHRE results to a theater-level combat effectiveness model, TACWAR, chosen in Phase I. The focus of Phase II was not to examine the particular alternatives modeled in C2PANTHRE, but to establish a methodology to examine theater-level C2 issues from performance and combat effectiveness perspectives. This study effort fulfills the theater-level requirement of C2FAM.

**1-4. Scope.**

*a.* The scope of this study was to examine the effect of C2 on all battlefield functional areas (BFA): intelligence, combat service support (CSS), maneuver, air defense artillery (ADA), and fire support. Additionally, the effect of C2 on air was examined to a lesser extent. As the primary focus of theater-level C2 is the allocation of resources, the greatest emphasis in this study was placed on CSS and intelligence.

*b.* The intent of the study was to develop a methodology to examine theater-level C2 issues independent of scenario. This would enable the methodology to be applicable for any region and timeframe. The scenario and alternatives were used merely as a basis for performing the study.

**1-5. Objectives.**

*a.* Establish the linkage criteria, in terms of the input parameters, between theater-level performance and combat effectiveness models.

*b.* Identify potential C2 measures of effectiveness (C2MOE) at the theater level.

*c.* Document lessons learned to aid the building of a new theater-level performance model and identify possible enhancements to the combat effectiveness model.

**1-6. Limitation.** The study results must be releasable to the U.S. and the U.K. (this limitation drove the selection of the scenario). It is assumed that the resulting methodology would apply for any scenario.

**1-7. Essential elements of analysis (EEA).**

*a. EEA 1. What are the linkage parameters between C2PANTHRE and TACWAR?* This EEA will be answered with the identified linkages for making the TACWAR runs. Additional linkages can be made by implementing enhancements to the models as identified in the answers for EEAs 4, 5, and 6.

*b. EEA 2. How sensitive is TACWAR output to variations in the identified input linkage parameters from C2PANTHRE?* This EEA is answered with the results from the TACWAR runs using the linkages identified for EEA 1.

*c. EEA 3. What are the appropriate MOE at the theater level, and can TACWAR measure them?* This EEA is answered by analyzing the results from the TACWAR runs. As this study is concerned with establishing a methodology rather than finding specific results, EEA 3 will include MOE that TACWAR cannot presently answer, but which are important for future C2 studies.

*d. EEA 4. What modifications are necessary in TACWAR to provide the most robust effectiveness analysis of C2 alternatives?* This EEA is answered through lessons learned in answering EEAs 1 and 3. The majority of the enhancements identified in this EEA will enable TACWAR to answer the MOE identified in EEA 3. Any additional enhancements recommended will be a result of lessons learned in establishing the linkage parameters between the performance model and TACWAR.

*e. EEA 5. As a result of this study, what recommendations can be made for the requirements of a new theater-level combat effectiveness model?* The completion of the study will provide information on the requirements of a new theater-level performance model. In particular, EEAs 1 and 3 will identify the key functions required in an effectiveness model for C2 studies.

*f. EEA 6. What lessons were learned which should be applied in developing another C2 performance model for a different area/region?* This EEA will be answered through running the C2PANTHRE performance model. In addition, answering EEA 1 by establishing the linkage parameters will identify the functional areas which must be included in future performance models to ensure a suitable linkage.

## CHAPTER 2

## STUDY APPROACH

**2-1. General.** As C2PANTHRE is a stochastic model, it was run five times for 15 days each and the outcomes averaged to give a representative result. These results, where appropriate, were then used in the TACWAR data base to show battle outcome. The 3.2.2 version of TACWAR was run using the Generic 1.0 scenario for five days.

**2-2. Alternatives.** The runs made for both models are described in the following paragraphs. Details on the linkage parameters between the two models are discussed in section 2-5e.

*a. C2PANTHRE.* The version of C2PANTHRE selected from Phase I was the proposed post-CFE NATO European central region structure with suggested staffing levels. Figure 2-1 shows the scope of the alternative and additional details can be found in reference a.

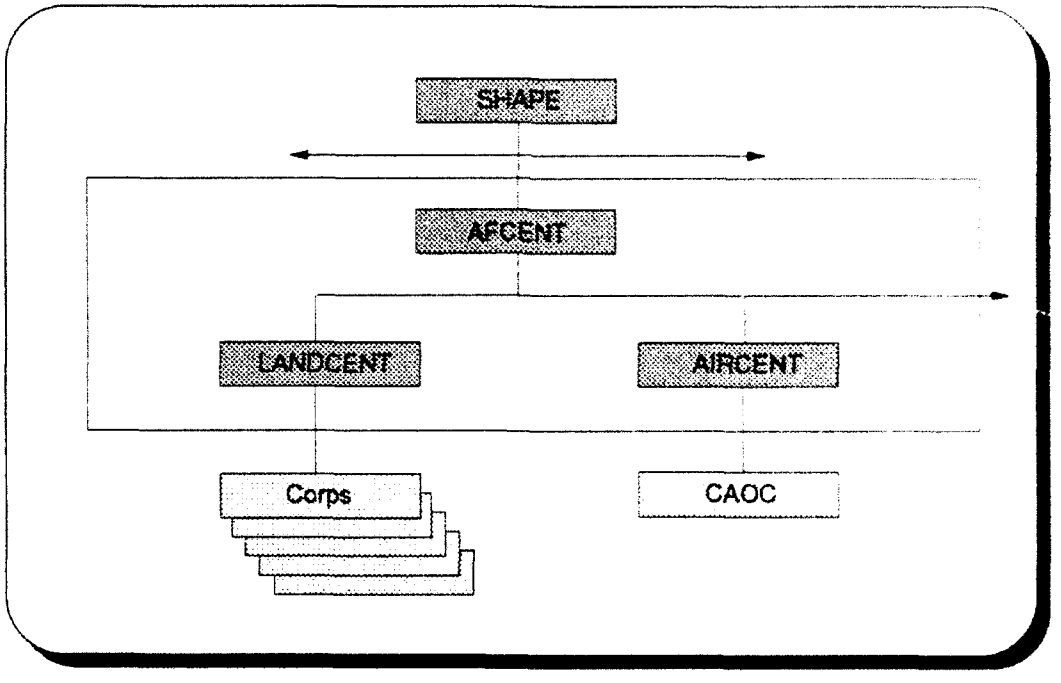


Figure 2-1. C2PANTHRE alternative

*b. TACWAR.* Eleven runs of TACWAR were made and can be found in table 2-1.

**2-3. Models/tools.**

*a. Modeler.* Modeler is a Petri net tool which enables the user to graphically represent the flow of information whether occurring sequentially or simultaneously. The information itself is not modeled.

Table 2-1. TACWAR alternatives

| Alternative | TACWAR variable altered | Description | Reason |
|---|---|---|---|
| Base case | | Blue initiates counterattack to reclaim Aville. Battle occurs around Sville. | Establish bench mark. |
| MO | UMOVR | Blue unopposed movement rates reduced 50%. | Represent bad Intelligence for Blue. |
| PO | KPIS | Red units in prepared defense (from hasty defense). | Represents bad Intelligence for Blue. |
| MOPO | UMOVR KPIS | MO and PO runs together. | Represents bad Intelligence for Blue. |
| DEL | | Blue delayed for 12 hours before attack begins. | Represent planning times from C2PANTHRE. |
| PER | PER | Number of Blue personnel in support units is halved. | Represents stressed logistics for Blue. |
| TRU | TRU | Number of Blue trucks in the support units is halved. | Represents stressed logistics for Blue. |
| SUD | SUD | Truck capacity at supply distribution points is halved. | Represents stressed logistics for Blue. |
| Extended PO | KPIS | PO run for extra day. | Ensure objective is reached and length of battle is identical to other runs. |
| Extended MOPO | UMOVR KPIS | MOPO run for extra day. | As for extended PO. |
| ASL | ASL | Days of supplies on-hand for each supply distribution point halved for depot, CSA, and DSA. | Represents delays in CSS requests and general stress on logistics system. |

*b. C2PANTHRE.* C2PANTHRE was developed using Modeler. It depicts the command staff elements of the NATO European central region: operations, logistics, intelligence, and plans. The headquarters of SHAPE down to corps and the equivalent air element, CAOC, are modeled with implicit representation of SHAPE, corps, and CAOC and explicit representation of the intermediate headquarters elements.

*c. TACWAR.* TACWAR, a theater-level combat effectiveness model, is deterministic with brigade unit resolution and a fixed 12-hour combat cycle. TACWAR represents ground, tactical air combat, target acquisition, nuclear/biological/chemical (NBC), and expanded CSS

*d. C2NET.* C2NET is a low-resolution C2 performance model developed by TRAC-OAC using Modeler. This model represents the fire support, maneuver, intelligence, ADA, and CSS elements within corps, division, and brigade command posts.

**2-4. Scenario.**

*a. Scope.* The Generic 1.0 scenario depicts a theater campaign that includes one U.S. corps, a five-division Blueland ground force, and U.S. Naval, Marine, and Air Force support. The threat forces include four corps and air forces. The scenario focuses on two battles: D+9, which is prior to full deployment and has the U.S. forces in defense, and D+75 with full deployment and where the U.S. forces conduct a counterattack. This study only used D+75 as it was felt important to concentrate on the offensive portion of the scenario. The D+75 scenario is illustrated in figure 2-2.

*b. Overview of terrain.* The conflict takes place in the spring of 2004 in a coastal nation on a Pacific continent (located approximately 5,000 miles west of the California coast at latitude 32° north). Terrain includes a coastal prairie, farmlands, and rolling hills with increasing vegetation inland. International commerce, oil, and technology are the major contributors to Blueland wealth. Blueland is bordered on the east by the neutral country of Greenland and on the west by the neutral country of Brownland. Sville, the capital of Blueland, is about 225 kilometers (km) from the coast and about 200km from the major port of Cville. Sville is also approximately 150km from the border of Redland. Redland borders Blueland on the north. Orangeland is an ally of Redland and borders Redland on the northwest. See figure 2-3.

*c. Theater environment.* The Generic 1.0 scenario is a low-resolution combat development scenario, depicting Redland invading its southern coastal neighbor, Blueland. U.S. forces, employing future doctrine, deploy and fight a regional threat. In D+75, the overwhelming U.S. forces conduct counteroffensive and deep operations to expel Redland forces.

*d. General situation.* Due to the generic nature of the scenario, no political preconditions are outlined, other than that Redland is a major regional power while Blueland is stronger economically. Redland attacks Blueland with minimum warning; Blueland is unsuccessful in the defense of its borders and delays southward. Blueland's strong point defenses develop around Sville (Blueland's capital) and its southernmost port city (Bville).

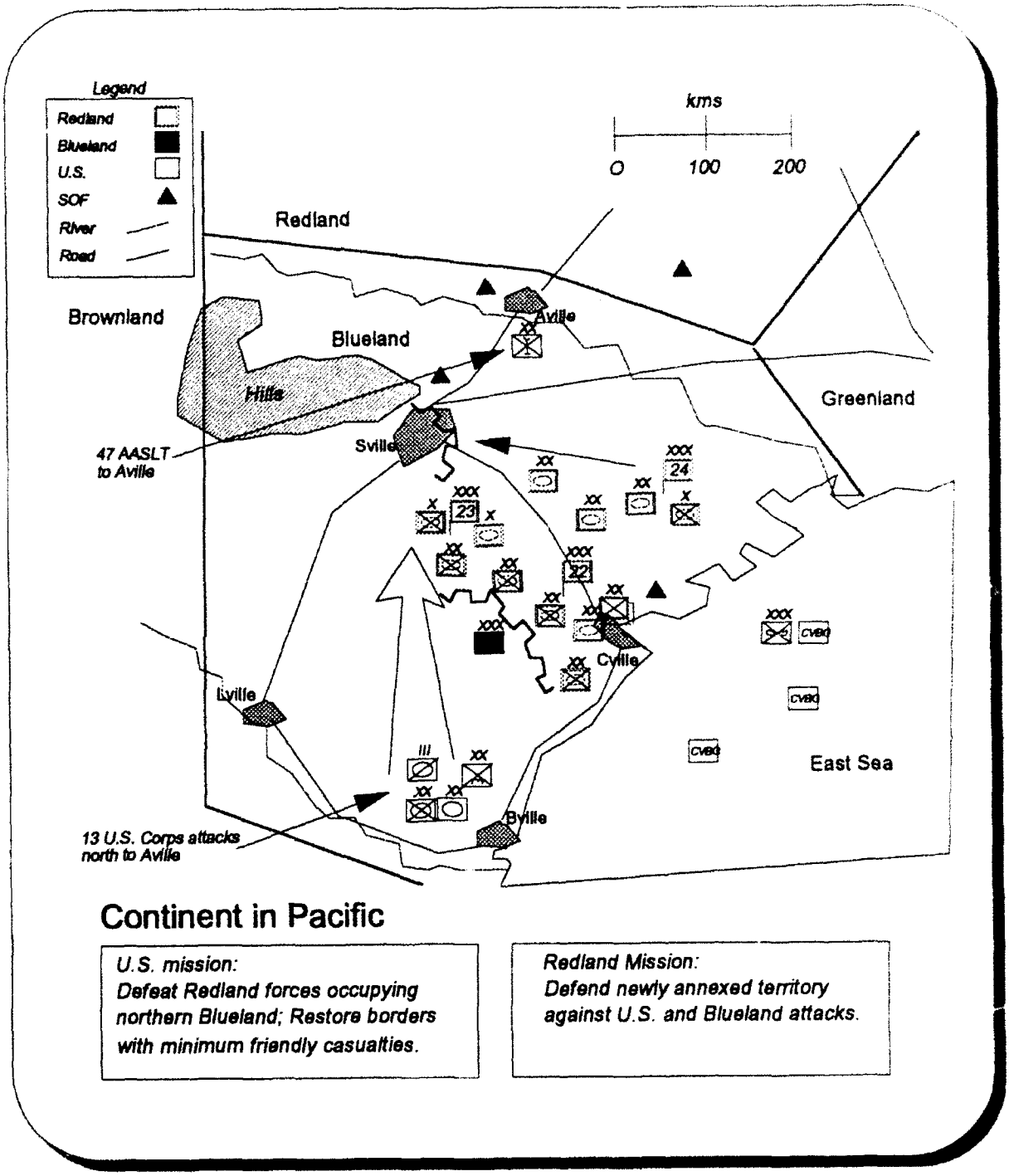


Figure 2-2. Theater - D + 75

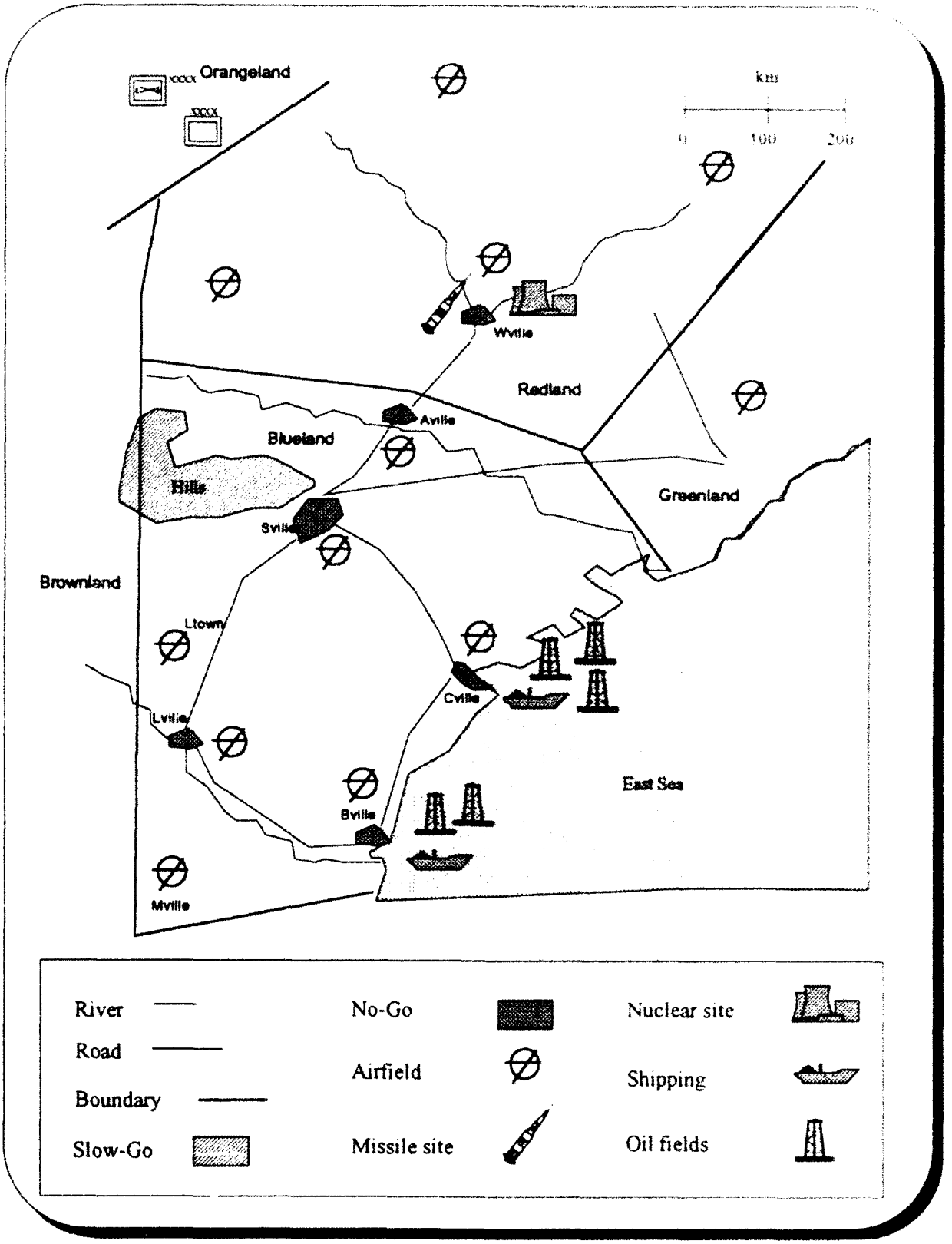


Figure 2-3. Area of operations

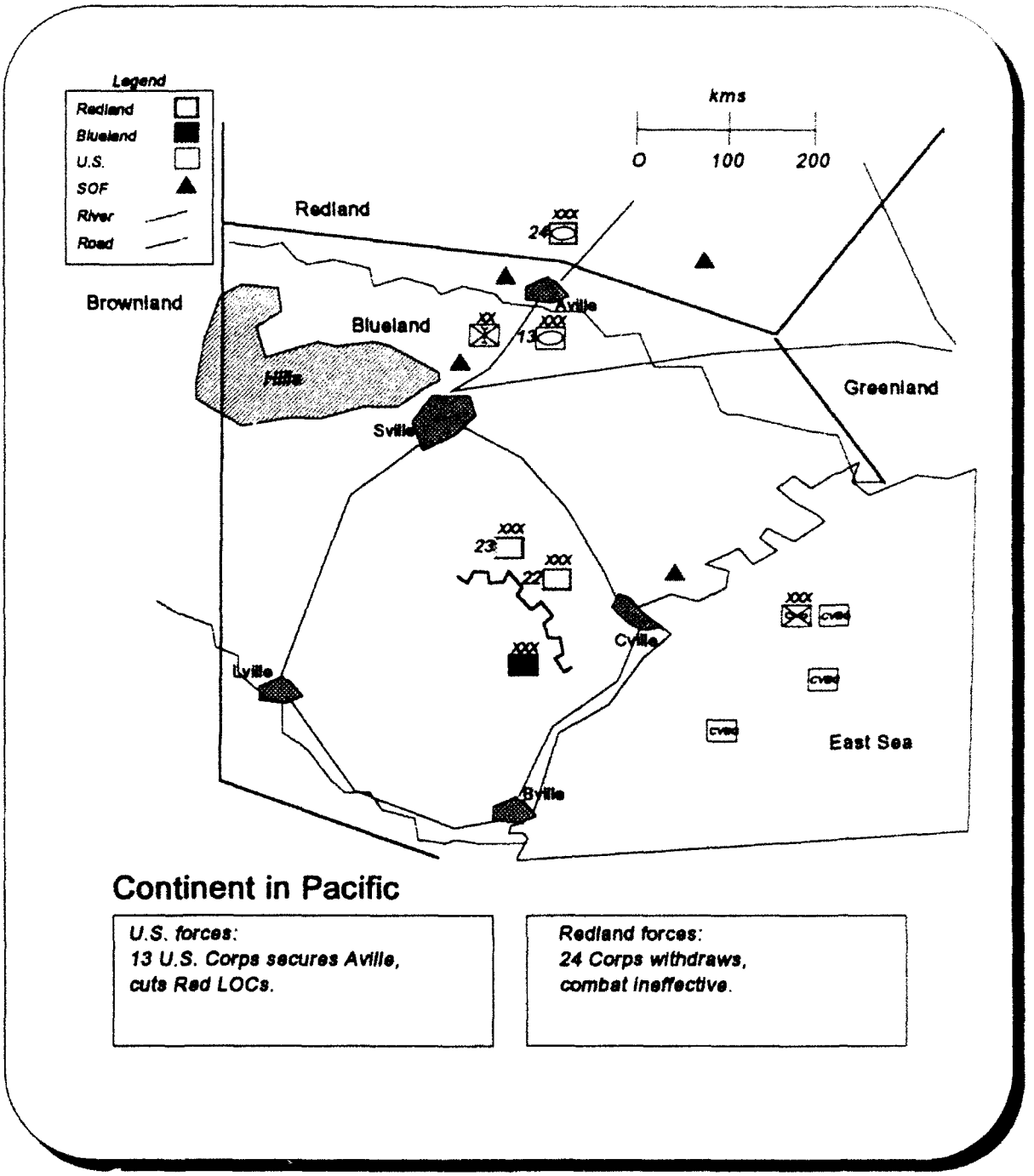


Figure 2-4. Theater - D + 80

(1) Blueland's government requests assistance and receives U.S. military assistance on the third day of hostilities. Redland's forces pause after accomplishing their objective of seizing the key Blueland port of Cville. Upon detecting the U.S.'s intent to become involved, Redland resumes the offensive to seize Blueland's only remaining port (Bville) and hence prevent U.S. deployment.

(2) Redland forces fail to prevent U.S. troops from fully deploying; therefore, at D+75, U.S. forces initiate a counterattack against Redland with the objective of retaking Aville and reestablishing the original borders. The 24th Corps of Redland moves west to intercept the U.S. forces and engage them in the vicinity of Sville. The two forces meet after 2.5 days and after 5 days, Blue has pushed Red from the vicinity of Aville, thereby, meeting its objective of reestablishing the original borders. Figure 2-4 illustrates the resulting positions after five days (at D+80). This corresponds to the base case run (see reference e for further details).

**2-5. Methodology.** The methodological process used in this study is shown graphically in figure 2-5. The following steps were taken to achieve the objectives and answer the EEA of the study.

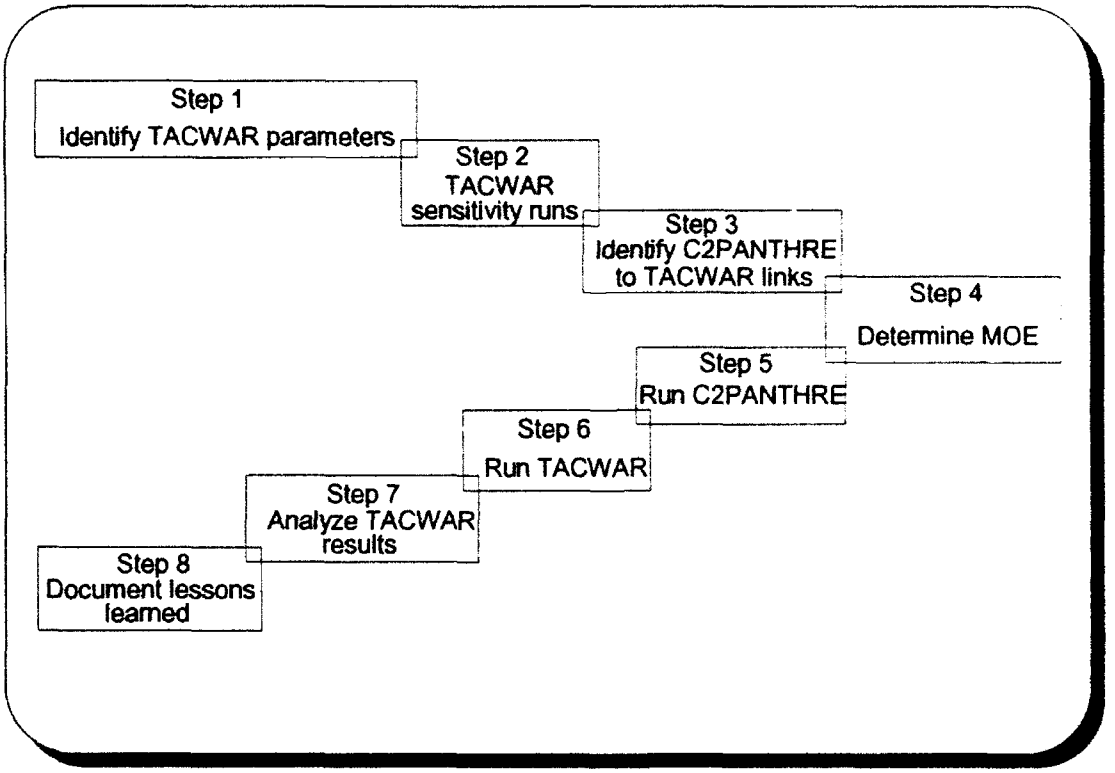


Figure 2-5. Methodology

*a. Step 1.* Determine possible parameters in TACWAR which changes in C2 could impact (regardless of whether there was a link from C2PANTHRE). This was the first step toward answering EEA 1.

*b. Step 2.* Perform sensitivity runs on the parameters identified in step 1. This helped in answering EEA 1 by further defining those parameters which, when altered, had significant impact on the battle. This step also assisted in answering EEA 2. However, EEA 2 was answered primarily with the results of the final TACWAR runs once the run matrix was defined.

*c. Step 3.* Determine which of the possible TACWAR parameters, identified in step 1, C2PANTHRE outputs could impact. This was part of the process in defining the TACWAR run matrix and in addressing EEA 1.

*d. Step 4.* Determine useful theater-level MOE, including C2MOE and force level MOE (FLMOE), to apply to TACWAR results. This answers EEA 3.

*e. Step 5.* C2PANTHRE and C2NET produced results for input to the TACWAR parameters identified in step 3. The post-CFE alternative in C2PANTHRE was run for 15 days. This run produced time delays for responses to corps requests for resources (intelligence and logistics) and a time delay at each headquarter element to receive, develop, and disseminate orders excluding communications time delays. Only the orders time delay for the theater element (LANDCENT, formerly known as Army Group) was used from C2PANTHRE. C2NET results (the average from five replications of a 10-day run using a post-CFE structure) provided the orders with time delays at corps and division headquarters. The delay times of the theater, corps, and division were added together and used to represent planning time in TACWAR. This time was used in TACWAR to delay Blue movement. Table 2-2 reflects the C2PANTHRE and C2NET results used, explicitly and implicitly, as inputs to TACWAR.

Table 2-2. Performance model outputs

| Description | Performance Model Results | Comments |
|---|---|---|
| Logistics time delay | 21 hrs | Used implicitly in PER, TRU, SUD, and ASL runs. To represent a lack of supplies due to delay. |
| Intelligence time delay | 18 hrs | Used implicitly in MO, PO, and MOPO runs to represent bad intel. |
| Orders time delay | 6 hrs Theater<br>4.5 hrs Corps<br>2.5 hrs DIV.<br>Total = 13 hrs | Approximated to 1 TACWAR cycle (12 hrs). Used explicitly in DEL run. |

*f. Step 6.* Run TACWAR. The 11 alternatives, noted previously in table 2-1, were investigated in TACWAR. The results can be found in section 3-1b. The runs determined how sensitive TACWAR was to the linkage parameters and helped determine suitable MOE.

*g. Step 7.* Analyze TACWAR run results using as many of the identified MOE in step 4 as possible. Other MOE from step 4 which were not attainable from TACWAR were identified as future MOE to examine given enhancements to the models.

*h. Step 8.* Identified model (performance and combat effectiveness) enhancements using insights from performing each methodology step. For example, if linkages were implicit and it was thought that an explicit link would be worthwhile, a recommendation for a model enhancement was made.

(1) Performance model enhancements were deemed worthwhile by evaluating each enhancement against the following criteria.

(a) What are the useful C2 measures of performance (C2MOP) from C2PANTHRE gained by this enhancement?

(b) What are the input parameters to TACWAR?

(c) Which MOE, C2MOE, and FLMOE, from TACWAR do the performance model enhancement contribute to?

(d) What is the possible impact on the battle as the result of this enhancement?

(2) TACWAR enhancements were evaluated and explained using the following criteria.

(a) What is the C2 input from the performance model?

(b) What TACWAR MOE does this enhancement affect?

(c) What is the possible impact on the battle?

# CHAPTER 3

# FINDINGS AND CONCLUSIONS

## 3-1. Answers to EEA.

*a. EEA 1. What are the linkage parameters between C2PANTHRE and TACWAR?* The following are the TACWAR parameters for which performance models can provide data and affect the outcome of the battle. The performance model outputs which link to these parameters are identified in paragraph 3-1d (page 3-6).

(1) UMOVR - Blue unopposed movement rates.

(2) KPIS - Red posture (changed from hasty defense to prepared defense).

(3) OBJCTV - Sets the objective for a unit.

(4) CDVLOC - Determines the unit's location.

(5) PER - Number of Blue personnel in support units.

(6) TRU - Number of trucks in support units.

(7) SUD - Truck capacity at supply distribution points.

(8) ASL - Days of supplies on-hand authorized for each supply distribution point.

*b. EEA 2. How sensitive is TACWAR output to variations in the identified input linkage parameters with C2PANTHRE?* A number of TACWAR runs were performed to test the sensitivity of the input parameters. Several parameters that were initially selected as potential linkages were rejected solely on the grounds that they did not appear to influence the model in terms of the battle outcome. An example of one of these parameters is "TNGMOD", the training factor. A reduction in the Blue training readiness did not impact on the battle. Another factor, "FCVLS" (which is a parameter that sets attrition rates), proved to be too sensitive in that even a minor change had the potential to vastly alter the battle outcome. This was rejected as a linkage parameter on the grounds that it would be impossible to ensure the differences in the battle outcome were solely the result of the change in attrition rate and not due to the internal workings of the TACWAR model. As table 3-1 shows, the parameters "UMOVR" (alternative MO) and "KPIS" (alternative PO) result in the most impact and are the most crucial linkage parameters.

Table 3-1. TACWAR results

| Alternative (TACWAR Variable) | Casualty Losses Red/Blue | Blue kills / Red kills | Ground Gained by Blue | Unit Strength (Weapon effect.) | Supplies provided/ consumed POL ammo other | Time to reach objective |
|---|---|---|---|---|---|---|
| Basecase | 11697/713 | 463/428 | 118 Km | 95% | 3198/4249<br>8884/10008<br>7200/8510 | 4.5 days |
| MO (UMOVR) | 9182/901 | 488/434 | 118 Km | 92% | 2514/4643<br>8297/13580<br>4159/6160 | 4.5 days |
| PO (KPIS) | 9730/4662 | 548/511 | 92 Km | 70% | 2232/3699<br>7294/7795<br>6238/9388 | Has not reached by end day 5 |
| MOPO (UMOVR KPIS) | 7518/1307 | 196/175 | 44 Km | 88% | 1202/4213<br>6122/11244<br>2882/5633 | Has not reached by end day 5 |
| DEL | 8819/994 | 640/601 | 116 Km | 92% | 3264/4398<br>8992/10087<br>6289/9499 | 5 days |
| PER (PER) | 11700/712 | 465/427 | 118 Km | 95% | 3375/4323<br>8920/10043<br>7368/8672 | 4.5 days |
| TRU (TRU) | 11404/714 | 451/429 | 118 Km | 95% | 3054/4222<br>8311/9467<br>6685/8109 | 4.5 days |
| SUD (SUD) | 10631/715 | 451/429 | 118 Km | 95% | 3062/4222<br>7877/9323<br>6867/8108 | 4.5 days |
| Extended PO | 12718/5746 | 683/2365 | 118 Km | 59% | 3733/3907<br>8641/9038<br>9319/9621 | 6 days |
| Extended MOPO | 10326/2603 | 317/974 | 118 Km | 76% | 1434/4315<br>6926/12165<br>5108/5413 | 6 days |
| ASL (ASL) | 11697/713 | 14/3 | 118 Km | 95% | 2850/4249<br>8884/10008<br>6910/8510 | 4.5 days |

*c. EEA 3. What are the appropriate MOE at the theater level, and can TACWAR measure them?* The MOE below are divided into the C2MOP from the performance model and C2MOE and FLMOE from TACWAR.

(1) C2MOP.

(a) **Processing time of orders per echelon**. This should include the time to develop orders under normal circumstances and time to develop orders when a command post is hit.

(b) **Processing time of intelligence requests**. This should be subdivided into the type of request made (for example, whether for existing information or for the gathering of information such as redirecting a satellite over a particular area).

(c) **Processing time of CSS requests**. These times should be broken into requests for different classes of supplies (classes III, V, IX , and other) and further defined by the nation and locale supplying the resource.

(d) **Processing time of battle damage assessment (BDA) results**. This includes the time from when the mission is completed to receipt of the analyzed BDA results at corps and division for preparation of a target list.

(2) C2MOE.

(a) **Time between identification of enemy and attack**.

1. This is the time that expires between the first positive identification of the enemy and the time an attack against that enemy is initiated. It assumes that once an enemy has been identified, an attack will be initiated immediately and, therefore, the time delay between identification and attack is due to the C2 process. Hence, the shorter the time between identification and attack, the better the C2 is.

2. It is currently not possible to measure this MOE in TACWAR. If a perception data base was built into TACWAR and the target acquisition module was divorced from the NBC, it should be possible to obtain this MOE. Any enhancements that are made to TACWAR should take into consideration that this MOE could be used in future studies.

(b) **Comparison of number of targets in range to number of targets identified**.

1. This MOE provides information on how good the intelligence is. With perfect information, the number of targets identified will equal the number in range; in other words, all targets are identified as they come into range.

2. Currently, TACWAR plays perfect information and this will have to be altered before this MOE can be utilized. The introduction of a perception data base will provide TACWAR with this capability.

(c) **Amount of supplies consumed/provided**.

1. This is a common measure to assess how well the CSS system performed. In an ideal situation, this ratio should be equal to, or just higher than 1. In reality, a comparison across alternatives, rather than against the perfect ratio, will show if supplies are getting through or if there are shortfalls.

2. This is a measure that TACWAR currently provides.

(d) **Synergy of deep fire assets**.

1. This can be evaluated via comparison of the number of kills by deep fire assets using perfect information to the number of kills with untimely information. This takes into account that improper intelligence results in multiple attacks on the same targets (hitting "dead" targets) and not hitting targets that were thought to be "dead."

2. TACWAR requires some enhancements before this MOE would become available. In particular, TACWAR must have a perception data base rather than rely on ground truth, and the target acquisition module must be in use.

(e) **Sufficiency of supplies to adequately engage available targets**.

1. This could be measured by comparing the number of targets in range by a unit at a key decision point to the amount of ammunition available to enable the unit to engage and kill those targets.

2. If the scenario is sufficiently complicated to enable key decision points to be identified, TACWAR could currently provide this MOE.

(3) FL MOE.

(a) **Time to mission accomplishment**.

1. This is the time that elapses between issuing a plan and reaching the objective listed in that plan. It assumes any delay in movement due to, for example, synchronization is consistent across alternatives and, therefore, the shorter the time to mission accomplishment the better the dissemination of that plan and, hence, the better the C2.

2. For TACWAR to provide this MOE, certain changes would have to be implemented. For example, at least part of the C2 process must be explicit. Currently in TACWAR, the devising of a plan is not modeled; hence, it is impossible to flag the time that the plan is finished. However, it is possible to determine when the objective is reached in the model ensuring that this MOE can currently be obtained, at least in part.

(b) **Comparison of mission intent to mission execution**.

1. This MOE relies on the model developing a plan, which can be accessed and later compared to the battle outcome. It assumes that the greater similarity between the projected plan and the final result, the better the C2 process.

2. Currently, it is possible to determine in TACWAR if the Blue units reached their final objective. This partially answers this MOE. To answer fully, it will be necessary to implement some changes in TACWAR. For example, the model must explicitly produce a plan which can be accessed at the end of a run.

(c) **Casualty losses**.

1. This is a more traditional MOE and simply compares the number of casualties on both sides between the various alternatives. This measure can be given in either absolute numbers or as a ratio of Blue to Red losses.

2. TACWAR can currently supply this MOE.

(d) **Killer/victim scoreboard**.

1. This MOE lists what was killed, and by what, for both sides. It, therefore, enables the user to determine what was the most effective weapon and the most vulnerable target.

2. TACWAR currently provides this information.

(e) **Ground gained/lost**.

1. This MOE compares the final position of the forward Blue units with their starting position. This represents the amount of ground gained or lost by Blue. Clearly, the more ground gained by Blue, the better they performed.

2. TACWAR already provides this information at the end of each run.

(f) **Unit strengths at key decision points**.

1. This measure provides information on the decisionmaking process. By determining the strengths at key decision points, it is possible to gain an insight into the decisionmaking process.

2. TACWAR has the capability to provide unit strengths at the end of each cycle. The key decision points are harder to identify in the model as C2 is currently not explicit. Therefore, the majority of the decisions are input rather than determined by the model itself.

*d. EEA 4. What modifications are necessary in TACWAR to provide the most robust effectiveness analysis of C2 alternatives?* Although TACWAR proved adequate for this study, a number of enhancements were identified which, if completed, would strengthen this methodology. The enhancements were either to strengthen the linkage between the performance and the effectiveness model or to analyze a C2MOE, or both. These modifications are discussed below under three categories: the linkage parameter involved, the MOE the modification would provide, and the expected impact on the battle.

(1) Add a perception data base to TACWAR. Currently, the units in TACWAR act upon ground truth; the impact of various intelligence assets are not realized. The addition of a perception database will strengthen the links with the performance model as demonstrated in the "MO", "PO", and "DEL" runs.

(a) C2PANTHRE inputs: Length of time to process intelligence reports; length of time to produce BDA reports (not currently modeled in C2PANTHRE).

(b) TACWAR MOE: Time between identification of enemy and attack; comparison of number of targets in range to number of targets identified; synergy of deep fire assets.

(c) Impact on the battle: In battle, no commander has the luxury of perfect information; the addition of a perception data base will greatly enhance the reality of TACWAR. This will also ensure that there is a delay between identifying a target and being able to bring the guns to bear. The introduction of BDA will result in overkill ("dead" targets being fired upon) and some targets will be declared "dead" when they are still active. This will also have implications for logistics.

(2) Activate the target acquisition module in TACWAR independently of the NBC module. This modification, coupled with the addition of a perception data base, will greatly enhance TACWAR's ability to play intelligence and BDA. This will use the processing times of intelligence requests and BDA results from the linkage enhancements made to the performance model identified under EEA 6. This is demonstrated by the "MO", "PO", and "DEL" runs.

(a) C2PANTHRE inputs: Length of time to process intelligence reports; timeliness of BDA information.

(b) TACWAR MOE : Time between identification of enemy and attack; synergy of deep fire assets.

(c) Impact on the battle: As target acquisition is a key component of any battle, its lack of representation in TACWAR reduces the model's usefulness. Its introduction will ensure that the model's representation of a battle is a bit closer to reality.

(3) Incorporate the BDA processing time from the performance model. This can be done by degrading a unit's probability of acquisition during the time the unit is awaiting analysis of BDA results. The probability of acquisition is a previously-mentioned enhancement.

(a) C2PANTHRE inputs: Processing time of BDA results.

(b) TACWAR MOE: Synergy of deep fires assets

(c) Impact on the battle: The introduction of explicit BDA will allow some targets to be killed more than once and others to be counted "dead" when they have not been taken out. This will have implications for the safety of the mission and for logistics with the potential for much higher use of ammunition.

(4) Model command posts explicitly in TACWAR. TACWAR already has this capability, but study efforts should utilize it. This would allow the command posts to be targeted and the impact to be felt on the battle. The time delays associated with developing orders and other C2 functions would be modeled in the performance model and input into TACWAR. The "DEL" and "ASL" runs demonstrate this.

(a) C2PANTHRE inputs: Processing time of orders per echelon; processing time of CSS requests, split into classes III, V, IX, and other; length of time to develop a plan.

(b) TACWAR MOE: Time to mission accomplishment; comparison of mission intent to mission execution.

(c) Impact on the battle: The most likely impact will be to make the battle tempo more realistic. By explicitly playing CPs, these CPs can be attrited and the C2 process impaired or destroyed. It will also allow the introduction of time delays representing the CP process which will slow down the battle.

*e. EEA 5. As a result of this study, what recommendations can be made for the requirements of a new theater-level combat effectiveness model?* As has been recognized at corps level, new combat effectiveness models must have explicit C2. It is no longer acceptable to assume perfect C2, and in particular, there must be a perception data base that can be accessed at key points during the battle. To ensure links between a performance model and a new combat effectiveness model, the effectiveness model should explicitly play CPs, which are attritable, and ideally, there should be times associated with tasks within those CPs. Clearly at a theater level, it is not necessary to get too detailed, but explicitly playing, for example, planning times would provide a clear and useful link between the two types of models.

(1) As has been mentioned earlier, key functions of theater C2 are logistics and CSS. This must, therefore, be played in any new combat effectiveness model in reasonable detail.

(2) It should be noted that many of the points discussed in this EEA can be put into TACWAR, given suitable time and resources. However, a new combat effectiveness model would have the advantage of C2 built in from the start, and not added on later as an afterthought.

*f. EEA 6. What lessons were learned which should be applied in developing another C2 performance model for a different area region?* C2PANTHRE provided a strong base with which to pattern the development of another theater-level C2 performance model. This study did not reveal any changes which should be made when developing another model; instead, a number of functions were identified which, if included, would strengthen the links between the performance model and TACWAR. The functional areas listed below are defined by four criteria explaining the utility of the enhancement, how it permeates the methodology, and what effect it could have when analyzing the theater-level battle.

(1) Model the processing time of evaluating BDA and sending the results back to the tactical units. Currently, C2PANTHRE represents the processing time for BDA but does not model the transfer of the BDA analysis back to the tactical unit. In reality, once the corps attacks a target, information is sent to the all-source analysis cell. Theater also performs BDA with possibly more reliable sources (e.g., satellites) and sends information back to the corps to analyze. The corps develops a target list incorporating the BDA results and plans which assets to use against the targets. If a corps gets BDA results in sufficient time before planning subsequent air or fire missions, there is a reduced chance of firing upon "dead" targets. Additionally, BDA results could identify that a mission was not successful and a further mission should be taken to destroy the target.

(a) C2MOP: Timeliness of BDA information received.

(b) Input to TACWAR: Use the C2MOP to adjust the effectiveness of subsequent missions (air or artillery) in the same sector. If the time between targeting missions (air or other deep fire) in the same sector was less than the processing time for BDA results, then the effectiveness of the subsequent missions would be reduced. This would represent the number of "dead" targets hit and the number of targets missed.

(c) MOE from TACWAR: Synergy between deep fire assets. This could be measured comparing the number of kills by deep fire assets using perfect information (timely BDA results) to the number of kills with untimely information.

(d) Impact on battle: In reality, the lack of timely information could impact the battle in several ways. Attacking a target twice (hitting "dead" targets) is a waste of resources which is important with the high cost of high-technology weapons. It also affects the quantity of resources on hand which may impact the unit's ability to fight subsequent battles. Untimely information may prolong the battle and possibly result in more casualties.

(2) Break out CSS requests into classes III, V, IX, and other. C2PANTHRE currently only models "generic" requests, assuming an average time and frequency for the processing of all requests. This enhancement would further define the requests by type and requesting nation/ organization requested from (e.g., received from host nation, flown from the continental U.S. (CONUS), etc.). Requests received by theater must be coordinated with the different supporting nations for their resources. This would aid in representing the effect of split-based operations.

(a) C2MOP: Length of time to process request (to include nation support time).

(b) Input to TACWAR: The C2MOP should link directly into TACWAR as the time delay for resupplying the supply points. This should more realistically represent the fact that some resources require a longer time to be supplied than others.

(c) MOE from TACWAR: (1) Amount of resources provided/consumed by class of supply. Is any supply point or unit at a CSS rating of "yellow" due to untimeliness in the processing of the CSS requests and sending of the requested supplies to the receiver? (2) Evaluate the sufficiency of supplies to adequately engage all available targets in range. This could be obtained from TACWAR by stopping the model at key decision points, determining the number of targets in range by all friendly systems, and comparing that number to the amount of ammunition available to sufficiently engage and kill the targets.

(d) Impact on battle: If resources are low, the planning options are limited. Units may be forced to be more conservative (e.g., defend ground instead of launching a counterattack or delay mission to await adequate supplies). If supplies are limited, a commander wanting to preclude a higher risk of casualties will avoid excessive risk and await resupply.

(3) Further define intelligence requests by category and by responding nation. The two categories would be: (1) requests for existing information, and (2) requests for additional intelligence gathering (e.g., redirecting a satellite to provide information). The responding nation holds the information or the resources to gather it. *C2PANTHRE currently* models intelligence requests as "generic."

(a) C2MOP: Timeliness of response to the intel request to include the time it takes for the requesting unit to receive the information.

(b) Input into TACWAR: (1) Explicitly, portray intelligence sources and input the time delay between the intelligence; (2) Implicitly, if there is no information on time before launching attack or moving to objective, etc., then Blue marches into Red when they were intending to go around them.

(c) MOE from TACWAR: (1) Time between identification of enemy unit and attack. (2) comparison between mission intent and mission execution (e.g., if the enemy is hit head on instead of on a flank and this was due to inadequate intelligence, then the mission execution was different from the intent). (3) Distance between where enemy force is identified and where attacked. This is not concerned with perception, but with the ability to track units, so that the greater the distance, the more timely the intel. (4) Number of targets (in range) identified at key points of the battle compared to actual number of targets within range. This involves an enhancement to TACWAR to be able to stop the model at decision points and compare a unit's perception base to ground truth. (5) Time to implement commander's intent. Improper intel can cause a delay in the mission or result in change in plan.

(d) Impact on battle Untimely or insufficient intelligence information affects the mission accomplishment This can be in terms of time, it can effect logistics by requiring more resources (bad intelligence can cause you to attack an enemy when the plan was to bypass them) In general, the commander's decision is only as good as his intelligence, so bad intelligence can result in more casualties, disrupt the flow of battle, and have an adverse effect on synergy

(4) Explicitly represent corps headquarters and model division as a receiver of orders, requests, etc This will enable a better integration with TACWAR since its resolution is at division level

(a) C2MOP All MOP are as stated in performance model enhancements 1, 2, and 3

(b) Input into TACWAR The inputs are the C2MOP

(c) MOE from TACWAR All MOE from TACWAR would benefit with this performance model enhancement

(d) Impact on battle The corps level is where intelligence information, resources, and orders are used to develop and execute the operational plan To make a constructive linkage between the performance and combat effectiveness models, the levels of resolution must be similar This is beneficial when analyzing the impact of C2 changes on force effectiveness

(5) Reflect clarification of orders (e g , retransmitting orders because the subordinate misunderstood them, did not receive them due to jamming, etc)

(a) C2MOP Time delay in developing and sending orders to subordinate units to include the time delay in sending reclarification of orders

(b) Input into TACWAR The C2MOP can be input implicitly by delaying a unit in moving to their objective or reducing the movement rates appropriately Explicitly, the time delay could be associated with sending orders from the CPs (this assumes an enhancement to TACWAR to model the transmission of orders to subordinates)

(c) MOE from TACWAR Time to mission accomplishment

(d) Impact on battle If orders cannot be clearly understood, the amount of planning time for the receiving headquarters is reduced This could lead to an inadequate plan or delay in mission execution which could cause a significant change of events in the battle For example, the enemy would have more time to prepare defensive postures, or the enemy might have moved requiring Blue to update their intelligence Blue's intention is to execute quick and decisive battles using the element of surprise whenever possible This intention is undermined when orders cannot be developed in a clear and concise manner, transmitted as soon as possible, and clearly understood by subordinates

## 3-2. Recommendations.

*a.* TRAC-OAC has recently assumed configuration control for TACWAR. At a recent TACWAR user's meeting, future enhancements to TACWAR were voted upon. This study recommends that the Command, Control, Communications, and Intelligence Studies and Analysis Directorate (C3I SAD) TRAC-OAC be involved in determining the specifics of all TACWAR C2 enhancements.

*b.* Appendix B contains the list of potential fixes and enhancements including work in progress and code error fixes that need to be resolved, major enhancements, and other requested changes. All the changes are prioritized. A decision on the exact format for the new version will not be made until April 1993 (after this report is finalized). It should also be noted that any new enhancements will have an extremely low resolution (not detailed).

## 3-3. Summary.

*a.* The study aim was not to answer any specific question but, rather, to establish a methodology for future studies. As such, the recommendations focus on future enhancements to both the performance and the combat effectiveness models and the development of appropriate C2MOE for future work. The specific enhancements and the C2MOE are detailed in section 3-1.

*b.* The results from this study suggest that there is no need to develop a new theater-level combat effectiveness model; all the requirements can be met by enhancing TACWAR. However, if a new model is to be developed, then C2 should be explicitly built in from the beginning.

*c.* Likewise, C2PANTHRE proved to be sufficient for the study but is tied to a specific theater of operations. If a study selects a different theater, then a new model will have to be developed.

*d.* The study has shown that it is feasible to link a performance model to a combat effectiveness model at the theater-level. TACWAR is sensitive to changes in its data base and, with a few changes, will be able to provide a number of C2 MOE, proving that this methodology has great potential for future studies.

# APPENDIX A

## Study Plan

Study Plan TRAC-SP-0792
September 1992

# STUDY PLAN

FOR

**PHASE II**
**UNITED STATES/UNITED KINGDOM (US/UK)**
**COMMAND AND CONTROL (C2) STUDY**

**PREPARED BY:**

**DONALD W. KROENING**
**Director, C3I Studies and Analysis Directorate**

**APPROVED BY:**

**ROBERT LA ROCQUE**
**Director, TRAC Operations Analysis Center**

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## STUDY PLAN
## FOR
## PHASE II
## UNITED STATES/UNITED KINGDOM COMMAND AND CONTROL STUDY

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**1. Purpose.** This plan will identify the study procedure and issues for Phase II of the combined United States/United Kingdom (U.S./U.K.) Command and Control (C2) study. Phase I culminated in the completion of the C2 performance model with a preliminary C2 analysis of different C2 structures. Phase II will build on this by using the model, C2 Performance Allied NATO Theater Europe (C2PANTHRE), developed in Phase I to test the principle of linking a C2 performance model with a theater-level combat effectiveness model. This includes determining appropriate measures of effectiveness (MOE) (to include both C2 MOE and measures of force effectiveness), providing lessons learned for building a new performance model (e.g., Korea), and establishing C2 requirements for a theater-level combat model.

**2. References.**

a. Defence Operational Analysis Establishment (DOAE), "Analysis of Alternative NATO C2 Structures Final Report - Phase I, Volumes 1, 2 and 3", Memorandum 92100, June 1992.

b. Combined Arms Combat Developments Activity (CACDA), "Army Command and Control Master Plan, Volume I", Desktop Reference, May 1990.

**3. Terms of reference.**

*a. Background.*

(1) The combined US/UK C2 study began in March 1991 between TRAC-OAC and the Defence Operational Analysis Centre (DOAC). The intent was to address the question: "What are the operational consequences of different theater and army group C2 structures in post-CFE [conventional forces-Europe] European conflicts?". This was to be accomplished in two phases.

(2) The Phase I focus was to develop a C2 performance model of the NATO European Central Region from SHAPE headquarters (hq) to corps and equivalent air hq element, Combined Air Operations Centre (CAOC). The aim of Phase II was to analyze post-CFE C2 alternatives of the aforementioned region from a combat effectiveness perspective. This was to be accomplished by establishing a linkage between the developed C2 model in Phase I (C2PANTHRE) to the theater-level combat effectiveness model selected in Phase I -- Tactical Warfare (TACWAR) model.

(3) However, due to a change in focus at DOAC, there is no longer a strong interest in the post-CFE NATO European Central Region C2 structure. Interest at DOAC has shifted to the

Allied Command Europe (ACE) Rapid Reaction Corps (ARRC) and its C2 structure. Nevertheless, it is important to continue the study to provide a proof of principle in linking the two models to assist future studies in addressing and analyzing C2 at theater-level and its effect on the battlefield.

(4) In TRAC-OAC, this study is part of the C2 Functional Area Model (C2FAM). C2FAM is an ongoing effort to develop performance models at division (DIVCP), corps (C2NET) and theater (C2PANTHRE) with linkage to their respective level of combat effectiveness model. C2FAM provides a capability to perform a qualitative and quantitative analysis of C2 systems and an inventory of analytic tools to support analysis. The scope of C2FAM is illustrated in figure ??.

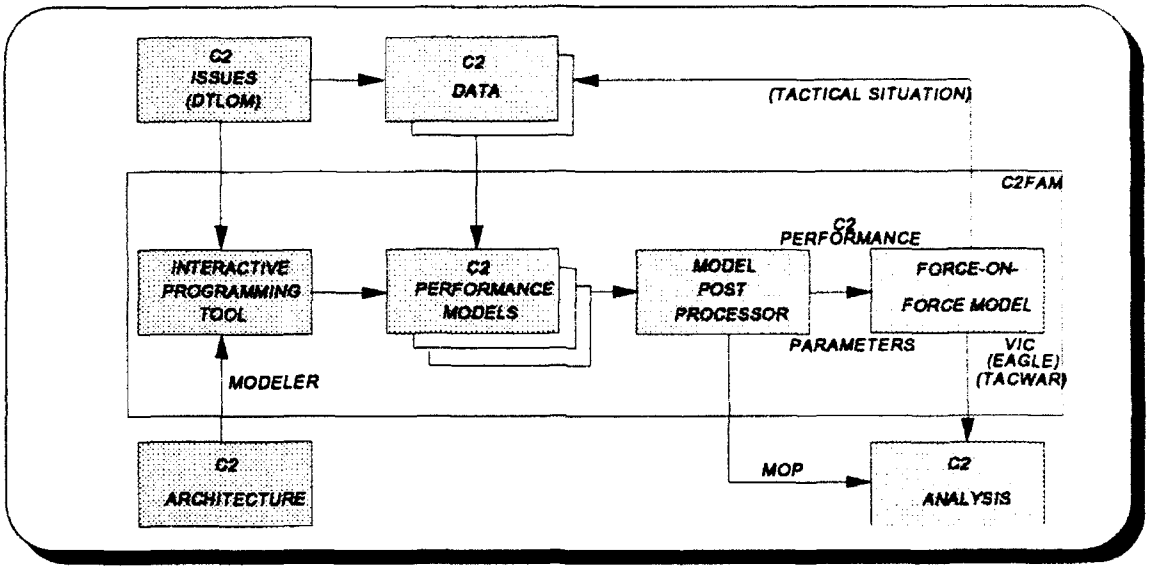


Figure 1. Command and Control Functional Area Model (C2FAM)

*b. Problem.* Theater-level analysis tools must address and adequately depict the operational plan that employs all theater assets in an orchestrated effort rather than just a grouping of tactical units. The theater-level commander is focused on joint operations and allocating resources to effectively plan contingency operations. As the focus of the theater-level commander and staff is different than that of tactical units of corps and below, the analytical world must be cognizant of the differences and adequately depict theater-level C2 in models and studies. Below are some issues which are uniquely associated with theater-level C2.

(1) How do we obtain interoperability in joint, combined or coalition force projection operations? This issue was identified in a battle lab. The theater campaign must achieve sequenced and synchronized employment of all land, air, sea, special operations, and space resources. Interoperability is a key element in realizing this goal.

(2) What are the bottlenecks in a theater C2 structure that must link to host nation, joint, and combined C2 structures? How can these bottlenecks be remedied, e.g., making staff changes, streamlining information, etc.?

(3) How should the theater command posts and C2 structure be designed to effectively establish support concepts and plan for theater operations?

(4) How can automation enhance the ability of the theater commander and staff to perform the C2 functions at theater level?

(5) What C3I assets are needed in the theater of operations versus CONUS or elsewhere when implementing split-based operations?

(6) What is the most effective deployment of theater staff to adequately transition from preparation to actual warfare? This issue was born out of the deployment of forces to Desert Shield. Support staff that would have been useful in the build up period were not deployed until the "higher priority" combat units had been deployed, thus yielding a less effective introduction of forces into the theater.

(7) How can the theater C2 process operate effectively to ensure appropriate allocation of resources and sustainment of the forces? Sustainment is the responsibility of the national and service organizations. Adequate theater-level C2 is required to ensure the integration of these resources complement the theater commander's campaign plan.

(8) How should the theater effectively prioritize resources, such as logistics and air assets, among the tactical units?

(9) How can the theater commander best organize his forces to conduct support, reception, reconstitution and protection operations? This issue is identified in reference 2b as one of the most important considerations a commander must make.

(10) Is there a need or requirement for headquarters above corps? Is there a requirement for a theater army? If not, what organization should perform the functions currently performed by theater?

*c. Impact of the problem.*

(1) Future theater-level studies are likely to focus on the above issues. A sufficiently robust methodology must be developed to adequately address these issues. This study is an effort to establish that methodology by identifying the requirements of a C2 performance model, establishing a linkage to a combat effectiveness model and analyzing the results for the C2 impacts on the battle. The C2 performance model provides a means to analyze alternatives from a C2 perspective and to provide input to the combat effectiveness model to more realistically depict theater-level C2. This enables a more robust analysis in theater-level C2 studies.

(2) Any changes that may be needed in TACWAR must be identified at the earliest possible stage to allow time for alterations to the model. This will also provide an ideal opportunity to determine the most suitable MOE at theater level and form the basis for future studies concerned with, for example, scenario support, the Standard Theater Army Command and Control System

(STACCS), Army Tactical Command and Control Systems (ATCCS) components as they are fielded at echelons above corps (EAC), the ARRC, and theater missile defense.

*d. Phase II objectives.*

(1) Establish the linkage criteria, in terms of the input parameters, between theater-level combat effectiveness and performance models.

(2) Identify potential MOE at the theater level.

(3) Document lessons learned to aid the building of a new theater-level performance model.

*e. Scope.* This study will primarily focus on the land aspect of the theater as the combat effectiveness model TACWAR has a limited representation of air. The study results will, however, include recommendations for enhancements to more appropriately address C2 of air assets.

*f. Essential elements of analysis (EEA).*

(1) EEA 1. What are the linkage parameters between C2PANTHRE and TACWAR?

(2) EEA 2. How sensitive is TACWAR output to variations in the identified input linkage parameters with C2PANTHRE?

(3) EEA 3. What are the appropriate MOE at the theater level, and can TACWAR measure them?

(4) EEA 4. What modifications are necessary in TACWAR to provide the most robust effectiveness analysis of C2 alternatives?

(5) EEA 5. As a result of this study, what recommendations can be made for the requirements of a new theater-level combat effectiveness model?

(6) EEA 6. What lessons were learned which should be applied in developing another C2 performance model for a different area/region?

*g. Methodology.* Each step of the methodology is detailed in the paragraphs below.

(1) Familiarization with TACWAR. To correctly identify the linkage parameters between TACWAR and C2PANTHRE, a good working knowledge of TACWAR will be needed.

(2) Identify linkage parameters between C2PANTHRE and TACWAR. These parameters must be the specific data elements in TACWAR for which C2PANTHRE will provide the data.

(3) Identify appropriate MOE. This includes determining how these MOE can be measured in TACWAR.

(4) Determine TACWAR sensitivity. Once the linkage parameters have been identified, a preliminary analysis of TACWAR results should be made to determine the sensitivity of the results to variations in the input. The aim is to achieve maximum sensitivity of TACWAR results, so steps 2 and 3 above should be repeated until the aim is reasonably attained.

(5) Perform TACWAR runs. The results from the sensitivity analysis will determine the run matrix for TACWAR. The runs will be made by the TACWAR modeling team at TRAC-Operations Analysis Center (OAC) with assistance from the study team to determine meaningful MOE.

(6) Analyze TACWAR results. This will determine that the MOE selected were appropriate and that TACWAR can be used to measure them.

(7) Document results. This will include any lessons learned to help in designing a new theater-level performance model (for example, in Korea), and the requirements for the combat model, both short- and long-term.

*h. Models and tools.*

(1) C2PANTHRE. C2PANTHRE is a C2 performance model of the NATO European Central Region headquarters developed in Phase I of the study. The scope of the model extends from Supreme Headquarters Allied Powers Europe (SHAPE) down to corps and Combined Air Operations Centre (CAOC) as shown in figure 2.

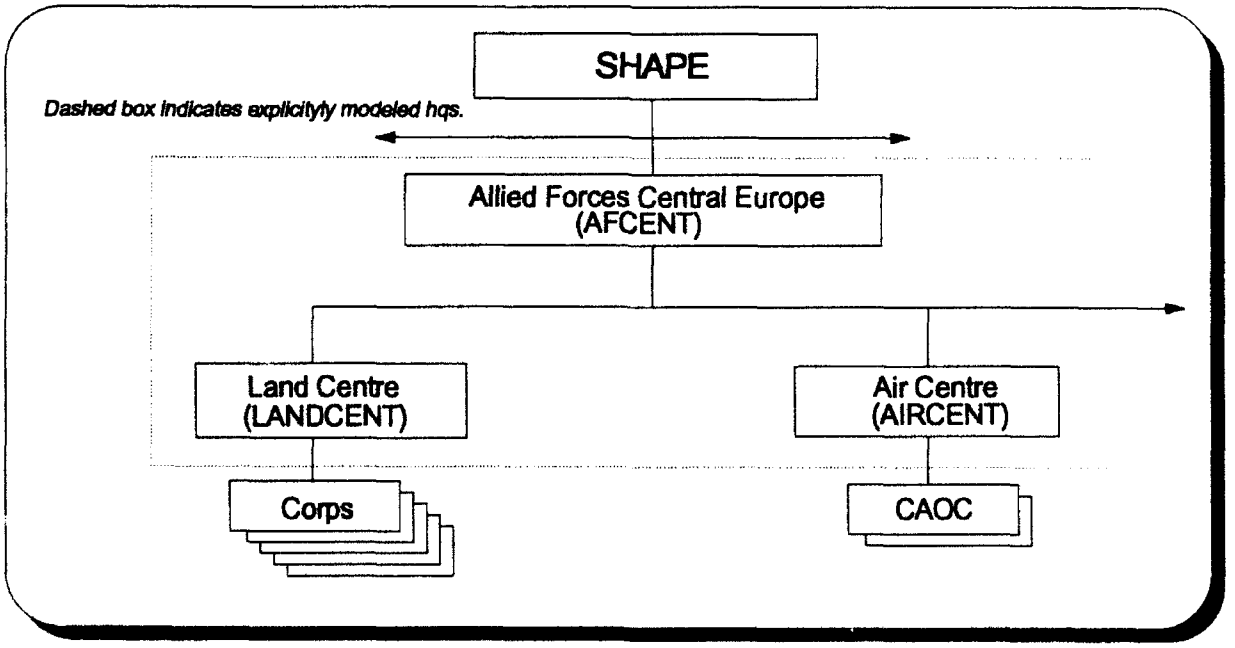


Figure 2. C2PANTHRE

(2) Modeler. Modeler is a Petri-net modeling tool used to develop C2PANTHRE in Phase I. As such, it will be used if any alterations to C2PANTHRE are required and as the medium in which to run C2PANTHRE.

(3) TACWAR. TACWAR is the theater-level force-on-force model selected in Phase I of the study for use in Phase II. The primary criteria for its selection were the availability of resources, C2 representation, and the existence of post-CFE scenarios already loaded in TACWAR.

*i. Scenarios.* In an attempt to standardize the process, the unclassified Generic 1.0 scenario in TACWAR was used. This has two advantages; first, it forces concentration on the procedure rather than on any specifics of the scenario. Second, as the scenario is unclassified, it should be releasable to the British.

(1) Scenario scope. The scenario depicts a theater campaign that:

(a) Includes one US corps, a five-division Blueland ground force, and forces of the US Navy, Marine, and Air Force. The threat includes four corps and air forces;

(b) Focuses on two battles:

- D+9 (prior to full deployment)
- D+75 (full deployment);

(c) And contains only limited detail (division-level) and theater-level missions and intents.

(2) Overview of terrain (see figure 3). The conflict takes place in the Spring of 2004 in a coastal nation on a Pacific continent (located approximately 5,000 miles west of the California coast at latitude 32 degrees north). Terrain includes a coastal prairie, farmlands, and rolling hills with increasing vegetation inland. International commerce, oil, and technology are the major contributors to Blueland wealth. Blueland is bordered on the east by the neutral country of Greenland and on the west by the neutral country of Brownland. Sville, the capital, is about 225 kilometers (km) from the coast and about 200 km from the major port of Cville. Sville is also approximately 150 km from the border of Redland. Redland borders Blueland on the north. Orangeland is an ally of Redland and borders Redland on the northwest.

(3) Theater environment. The scenario is a low-resolution combat development scenario, depicting Redland invading its southern coastal neighbor, Blueland. US forces,employing future doctrine, deploy and fight a regional threat. Figure 4 shows the scenario events' timeline.

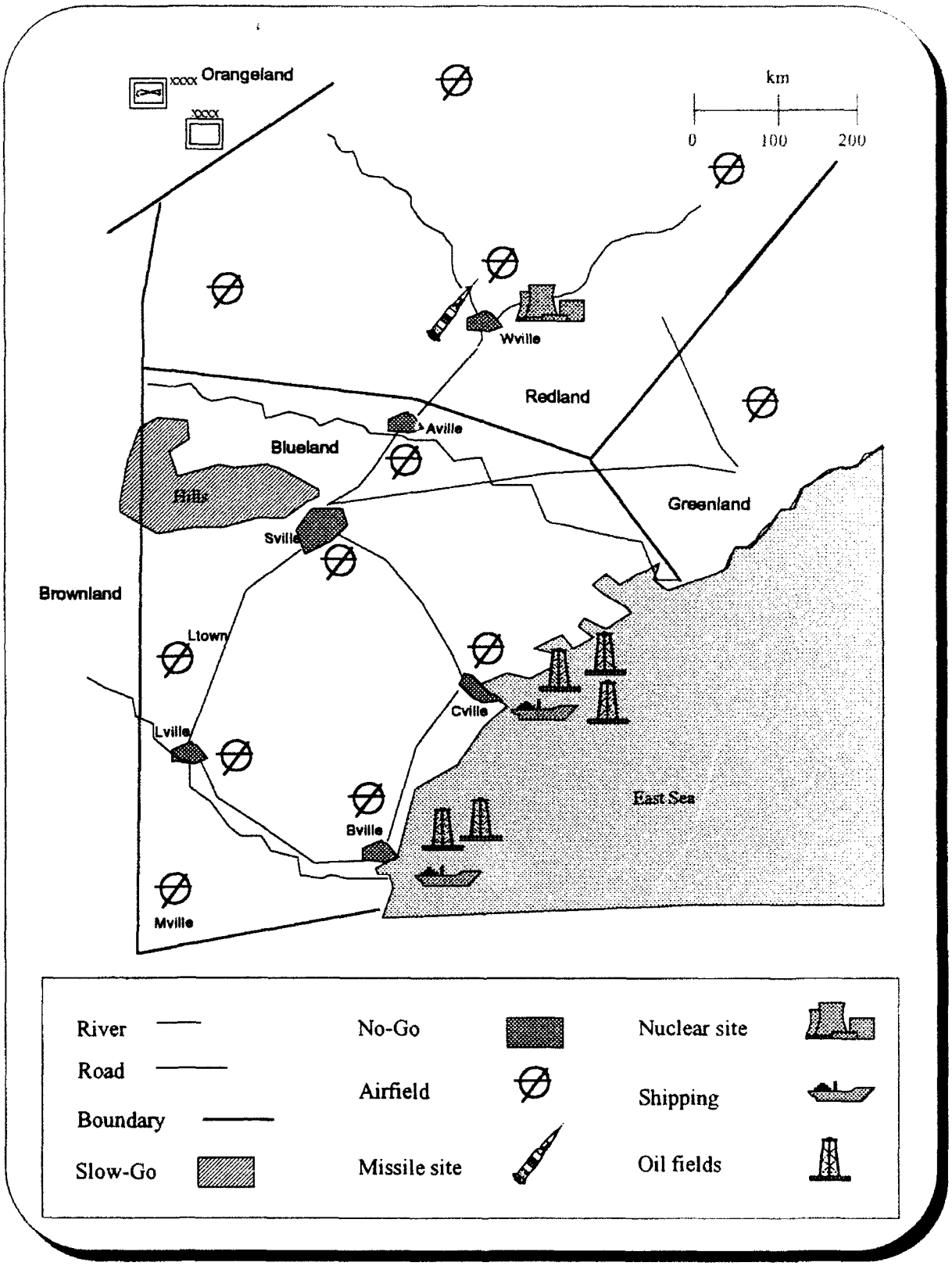


Figure 3. Area of operations

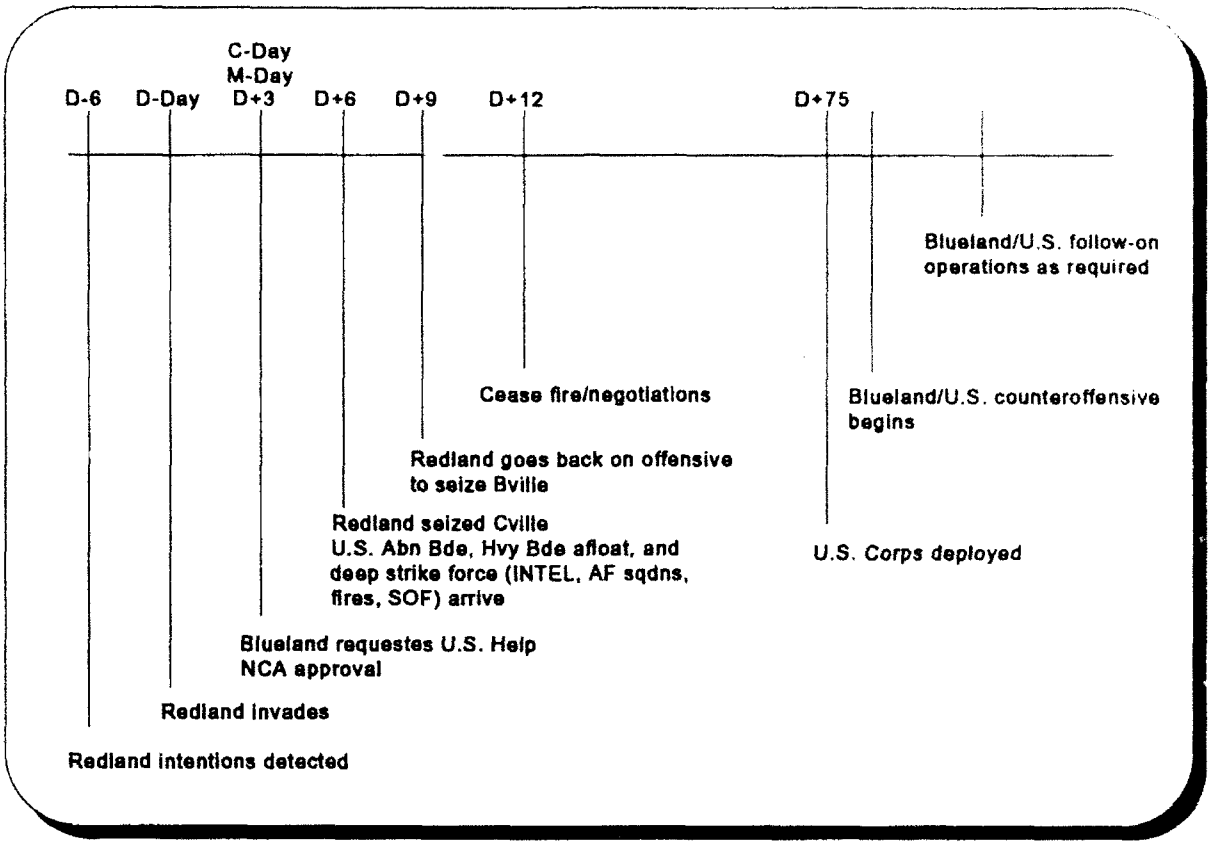


Figure 4. Scenario events' timelines

*j. Alternatives.* C2PANTHRE has two alternatives: a proposed post-CFE structure with current manning levels and a proposed structure with a suggested level of manning for each headquarters based on the analysis results of Phase I. Using two alternatives will enable examination of TACWAR's suitability to variations in inputs.

*k. Measures of effectiveness (MOE).* The following are examples of the kind of MOE that will be investigated. As EEA 3 is to determine appropriate theater-level MOE, the list should not be regarded as the definitive set.

(1) Timeliness of battlefield maneuvers (for example, are the orders, resources, intelligence, and information received by corps and CAOC, in sufficient time to plan and execute the battle?).

(2) Time between follow-on force identification and attack.

(3) Time to implement commander's intent.

(4) Degree of available joint service integration.

**3. Support and resource requirements.**

*a. Support requirements.*

(1) The Command, Control, Communications, and Intelligence Studies and Analysis Directorate (C3I SAD), TRAC-OAC, will:

(a) Acquire a working knowledge of TACWAR.

(b) Determine, in detail, the linkage between C2PANTHRE and TACWAR.

(c) Identify suitable MOE and how they can be determined in TACWAR.

(d) Assist the Production Analysis Directorate (PAD) in performing a sensitivity analysis of TACWAR results given the identified linkage parameters to C2PANTHRE and revise them as required to maximize sensitivity.

(e) Perform any required C2PANTHRE runs.

(f) Define the run matrix for TACWAR.

(g) Answer the EEA and analyze the MOE identified in EEA 3.

(h) Write the Phase II report, to include any lessons learned.

(2) PAD, TRAC-OAC, will:

(a) Perform a sensitivity analysis of TACWAR results given the identified linkage parameters to C2PANTHRE and revise them as required to maximize sensitivity.

(b) Assist C3I SAD in identifying suitable MOE and how they can be determined in TACWAR.

(c) Advise C3I SAD in determining the run matrix for TACWAR.

(d) Perform the TACWAR runs.

(e) Assist C3I SAD in analyzing the MOE identified in EEA 3.

(f) Identify any revisions to TACWAR necessary to accommodate linkage with the performance model.

*b. Resource requirements*

(1) C3ISAD 6 man-months Aug 92-end Jan 93

(2) PAD 2 man-months Nov 92-end Dec 92

**5. Administration.**

*a. Study schedule.*

| MILESTONE | DELIVERY DATE |
|---|---|
| Familiarity with TACWAR | end Aug 92 |
| Identify C2PANTHRE and TACWAR linkage parameters | end Sep 92 |
| Identify MOE | end Oct 92 |
| Perform TACWAR sensitivity runs | end Oct 92 |
| Run TACWAR and analyze output | end Dec 92 |
| Final briefing | Dec 92 |
| Final Phase II report | end Jan 93 |

*b. Study review group.* The study review group will consist of

- Dr Robert LaRocque, Director, TRAC-OAC
- Mr Donald Kroening, Director, C3I SAD, TRAC-OAC
- Mr Ernest Boehner, Director, PAD, TRAC-OAC
- LTC Thomas Pawlowski, Chief, C2 Division, C3I SAD, TRAC-OAC

*c. Study project officer.* The study project officer is Ms Lynn Swezy, C3I SAD, (913) 684-5418

**6. Correlation.** The activity control number (ACN) for this effort is 5060

**7. Concurrences.** This plan was coordinated with and concurred by directors of TRAC-OAC's Models Directorate and Production Analysis Directorate as well as the Chief of the Louisiana Maneuvers Task Force (LAM)

# APPENDIX B

# PLANNED TACWAR ENHANCEMENTS

Working CCR's and Fixes (list For Prerelease)

AS OF 12 FEB 93
TOM ITEN PSE LVN

Prerelease Working List

| CCR No | Category | Title | Submitting Organiz | Designated DA | Status |
|---|---|---|---|---|---|
| 920060 | ENH | ALLOCATION OF FIRE REVIEW AND UPDATE PROCESSOR | J-6/ASD | PSE ANNANDALE | Pre Design Anal |
| 920061 | ENH | REVISION OF OUTPUT TABLES | CENTCOM | CENTCOM | Partial Imp |
| 920062 | ENH | PROPOSED CHANGES FOR "WEAPON SCORE" CALCULATIONS IN TACWAR | J-6 | PSE ANNANDALE | Pre Design Anal |
| 920063 | ENH | IMPROVED HELO PLAY | J-6/CFAC | IDA | Pre Design Anal |
| 920064 | ENH | PROVIDE CAPABILITY TO MASS ARTILLERY FIRES | J-6/CFAC | IDA | Pre Design Anal |
| 920074 | ENH | PROPOSED CHANGES FOR GROUND COMBAT (GC) "ALLOCATION of FIRE" CALC | J-6/ASD | PSE ANNANDALE | Pre Design Anal |
| 920075 | ENH | DOCUMENTATION AND SOURCING OF ATTRITION INPUT PARAMETERS | J-6/CFAC | IDA | Det Design Comp |
| 920087 | ENH | CHEMICAL SUBMODEL | CENTCOM | CENTCOM | Pre Design Anal |
| 920201 | ENH | XTWG SECTOR PREPROCESSOR | CENTCOM | CENTCOM | Pre Design Comp |
| 920202 | ENH | XTWG PLAYBACK PREPROCESSOR | CENTCOM | CENTCOM | Pre Design Comp |
| 920203 | ENH | XTWG UNIT PREPROCESSOR | CENTCOM | CENTCOM | Pre Design Comp |
| 920204 | ENH | XTWG-ADD GIR BROWSER CLASS TO GETOOLKIT | CENTCOM | CENTCOM | Pre Design Comp |
| 920205 | ENH | XTWG TERRAIN POSTURE FEBATZ PREPROCESSOR | CENTCOM | CENTCOM | Pre Design Comp |
| 920206 | ENH | WRITE A TACWAR AIR PREPROCESOR USING GRAPHICS SERVER | CENTCOM | CENTCOM | Pre Design Comp |
| 920207 | ENH | WRITE A TACWAR LOGISTICS EDITOR USING THE GRAPHICS SERVER | CENTCOM | CENTCOM | Pre Design Comp |
| 920208 | ENH | WRITE A TACWAR LOGISTICS POSTPROCESSOR USING THE GRAPHICS SERVER | CENTCOM | CENTCOM | Pre Design Comp |
| 920209 | ENH | XTWG ADD A TABLE OBJECT CLASS TO GETOOLKIT | CENTCOM | CENTCOM | Pre Design Comp |

Fixes

| CCR No. | Category | Title | Submitting Organiz | Designated DA | Status |
|---|---|---|---|---|---|
| 920080 | FIX | RENUMBERING OF OUTPUT TABLES | J-6/ASD | CENTCOM | Partial Imp |
| 920099 | FIX | PROBLEMS WITH UNIT MOVE | CENTCOM | OPEN | |
| 920106 | FIX | ADDITION OF SUMMARY TABLE CODE | J-6/ASD | CENTCOM | Det Design Comp |
| 920150 | FIX | TIME-TYNG NEW INDEX TO SECTOR ATTACKER (SA) | J-6/ASD | PSE LVN | Redesign |
| 920164 | FIX | DISPLACEMENT DATA ON TABLE | USCENTCOM | PSE LVN | Pre Design Comp |
| 920165 | FIX | UNDEFINED EXPONENTIATION IN ATTRITION | CENTCOM | PSE LVN | Pre Design Comp |
| 920166 | FIX | REMOVAL OF UNUSED VARIABLES | CENTCOM | OPEN | |
| 920167 | FIX | CALCULATION OF UNIT'S CONTRIBUTION OF DIRECT FIRE WEAPONS | CENTCOM | OPEN | |
| 920168 | FIX | ERROR IN UNIT/OBJECTIVE INPUT IN TIMET | CENTCOM | OPEN | |
| 920172 | FIX | WEAPON VALUE CALCULATION IN GC | PENTAGON | OPEN | Pre Design Anal |
| 920179 | FIX | CLOSING OF SCALED WINDOW KILL ENTIRE RUN | USEUCOM | PSE LVN | Pre Design Anal |
| 920188 | FIX | AIRCRAFT SAM SUPPRESSIONMISSIONS NOT FLYING PROPERLY | USEUCOM | OPEN | Pre Design Anal |
| 920191 | FIX | PARAMETER DECLARATION | J-6/ASD | OPEN | |
| 920192 | FIX | CORRECTION OF MOVEMENT DELAY LOGIC | CENTCOM | OPEN | |
| 920197 | FIX | USE OF TWO VARIABLE (TOE ACTUAL WEAPON TYPE) | USEUCOM | OPEN | OOC ONLY |
| 930216 | FIX | SVP DAT ERROR FOR SONCUS | CENTCOM | OPEN | Pre Design Anal |
| 930217 | FIX | DEAD SSM VARIABLE | CENTCOM | OPEN | Pre Design Anal |
| 930238 | FIX | CODE ERROR IN SUBROUTINE LOSSES FOR | CENTCOM | OPEN | One Liner |
| 930239 | FIX | CODE ERRORS ASSOCIATED WITH SURVIVABLE CORRIDORS AND STAND-OFF MUNITIONS | CENTCOM | OPEN | Pre Design Anal |
| 930240 | FIX | CALCULATION OF WEAPON LOSSES WHEN MVCASO = 1 | CENTCOM | OPEN | One Liner |
| 930241 | FIX | ELIMINATION OF MVCASO = 2 AND MVCASO = 3 | CENTCOM | OPEN | Pre Design Anal |
| 930243 | FIX | INCORRECT COMPUTATION IN SUBROUTINE LOSSES FOR | CENTCOM | OPEN | Pre Design Anal |
| 930245 | FIX | BAD AIRBASE UPDATE DURING INTERACTIVE RUN | J-6/CFAD | OPEN | Pre Design Anal |
| 930246 | FIX | INCORRECT VARIABLE INDEX USED IN DISTANCE | J-6/CFAD | OPEN | Dtl Listing |
| 930247 | FIX | INCORRECT VARIABLE USED TO COMPUTE PERSONNEL CASUALTIES AT PORTS | J-6/CFAD | OPEN | Dtl Listing |
| 930248 | FIX | DELAY CALCULATION ERROR IN CALC_POSITION FOR | J-6/CFAD | OPEN | Dtl Listing |
| 930249 | FIX | DIVIDE-BY-ZERO ERROR CHECK IN FEBAMT | J-6/CFAD | OPEN | Pre Design Anal |
| 930250 | FIX | REASSIGNMENT OF AIRCRAFT ARRIVING AT INCORRECT AIRBASE | J-6/CFAD | OPEN | Pre Design Anal |

Sorted CCR's Based On Voting Member Prioritization

MAJOR

| CUMM SCORE | J @ | C E | A U | K O | M C | E U | T R | CCR No. | Category: | Title: | Submitting Org/site | Submitter Priority |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 20 | 17 | | 6 | 10 | 7 | 10 | 930219 | IMP | ENHANCEMENT FOR MODELING COMMAND AND CONTROL | USEUCOM | 1 |
| 75 | 17 | 16 | | 2 | 9 | 10 | 22 | 930213 | IMP | REVISION TO CLOSE AIR SUPPORT (CAS) LOGIC | CENTCOM | 2 |
| 116 | 13 | 15 | | 43 | | 19 | 26 | 930225 | IMP | UNCLASSIFIED DATA BASE | J-8/CFAD | 2 |
| 115 | 14 | 21 | | 41 | | 14 | 25 | 930218 | IMP | CONVERSION TO SVR4 POSIX | J-8/ASD | |

OTHER

| CUMM SCORE | J @ | C E | A U | K O | M C | E U | T R | CCR No. | Category: | Title: | Submitting Org/site | Submitter Priority |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | 930220 | IMP | DESCRIPTIVE ERROR MESSAGES FROM TIE / IMPROVE TACWAR AUDIT DBG OUTPUT | J-8/CFAD TRAC-LVN | 1 |
| 2 | | | | | | | | 920189 | ENH | SAMMAX VALUES LIMITS POINT SAMS TO ONE SHOT PER TARGET | USEUCOM | 2 |
| 3 | | | | | | | | 920185 | IMP | ASSOCIATION OF UNIT HELD SAM/AAA SYSTEMS WITH THE APPROPRIATE PT SAM | USEUCOM | 2 |
| 4 | | | | | | | | 920184 | IMP | POINT SAM SYSTEMS LIMITED TO THE NUMBER OF CLASS 4 GROUND WEAPON SYSTEMS | USEUCOM | 2 |
| 5 | | | | | | | | 920188 | IMP | PK PRE-PROCESSOR | J-8/ASD | 2 |
| 6 | | | | | | | | 920191 | IMP | ADD VARIABLES TO WEATHER ABORT AIRCRAFT SORTIES | J-8/CFAD | 1 |
| 7 | | | | | | | | 920154 | IMP | DATABASE DOCUMENTATION | J-8/ASD | 2 |
| 8 | | | | | | | | 930214 | IMP | IMPROVE READABILITY OF TACUTL DIAGNOSTICS | CENTCOM | 4 |
| 9 | | | | | | | | 930211 | OOO | ADJUSTMENT TO AIRCRAFT LOADS (VARIABLE AMMLAF) | CENTCOM | 1 |
| 10 | | | | | | | | 920186 | IMP | EFFECT OF PARKING SPACES ON ATTRITION OF AIRCRAFT ON GROUND | USEUCOM | 2 |
| 11 | | | | | | | | 920182 | IMP | TACUTL ALWAYS WRITES FILES TO THE ACCOUNT'S HOME DIRECTORY | USEUCOM | 2 |
| 12 | | | | | | | | 920187 | IMP | RE-DESIGN OF POINT AND AREA SAM OUTPUT TABLES | USEUCOM | 2 |
| 13 | | | | | | | | 930222 | OOO | DATA TABLES BY CYCLE | TRAC-LVN | 1 |
| 14 | | | | | | | | 930227 | IMP | SUMMARY OUTPUT TABLES, MISSING VALUES | J-8/ASD | 2 |
| 15 | | | | | | | | 920196 | IMP | ADDITION OF GRAPHICS AND COMPUTATIONAL HOSTS TO DEFAULT FILE | J-8/CFAD | 1 |
| 16 | | | | | | | | 920195 | IMP | COMBAT UNIT RECORD CONSISTENCY | CENTCOM | 2 |
| 17 | | | | | | | | 930229 | ENH | SUMMARY OUTPUT TABLES, ENHANCED HEADINGS | J-8/ASD | 2 |
| 18 | | | | | | | | 920193 | IMP | VERIFY FAAB AIRBASE | CENTCOM | |
| 19 | | | | | | | | 920179 | ENH | ATTRITION DATA VERIFICATION | USCENTCOM | 2 |
| 20 | | | | | | | | 920197 | IMP | NEED FOR USER SPECIFIABLE MIN/MX LATA/LONG WINDOW | J-8/CFAD | 2 |
| 21 | | | | | | | | 930226 | OOO | REWORK OF DETAILED TABLE REPORTS | J-8/CFAD | 2 |
| 22 | | | | | | | | 920194 | IMP | CDVLOG AND OBJCTV FOR COMBAT UNIT | CENTCOM | 2 |
| 23 | | | | | | | | 930212 | IMP | CONVERSION OF PHIGS GRAPHICS INTO XFIG DATA FILES | CENTCOM | 2 |
| 24 | | | | | | | | 920181 | IMP | RUNNING IN BATCH MODE REQUIRED SELECTING A GRAPHICS HOST | USEUCOM | 2 |
| 25 | | | | | | | | 930228 | IMP | NEW SUMMARY TABLE, BLUE ADVANCE BY SECTOR | J-8/ASD | 2 |
| 26 | | | | | | | | 920060 | ENH | PUBLISH TACWAR USER'S GUIDES FOR SUNS | CFCD KOREA | 2 |
| 27 | | | | | | | | 920175 | OOO | ADDITION OF SCALE NUMBER TO BANNER FOR BANNER FOR PULLDOWN SCALE VIEWS | PENTAGON | 2 |
| 28 | | | | | | | | 920008 | ENH | USE OF QTQTYN FOR AND QTQVA FOR SHOULD BE EXPANDED | J-8/ASD | 2 |
| 29 | | | | | | | | 920183 | ENH | SPLIT QC INTO CONTROL ROUTINE AND SUBROUTINES | CENTCOM | |
| 30 | | | | | | | | 920073 | ENH | PUBLISH NEW NUC ANALYST'S GUIDE | CFCD KOREA | 2 |
| NEW | | | | | | | | 930242 | IMP | SIMPLIFICATION OF SUPPORT UNIT MOVE LOGIC | CENTCOM | 2 |
| NEW | | | | | | | | 930244 | ENH | TACWAR MUNITIONS GRAPHICS | J-8/CFAD | 2 |

# APPENDIX C

# GLOSSARY

## APPENDIX C

## GLOSSARY

| | |
|---|---|
| ACCS | Army Command and Control System |
| ADA | air defense artillery |
| AFCENT | Allied Forces Central Europe |
| AIRCENT | Air Centre |
| ASL | days of supplies on-hand (TACWAR parameter) |
| ATCCS | Army Tactical Command and Control System |
| BDA | bomb damage assessment |
| BFA | battlefield functional area |
| C2 | command and control |
| C2FAM | C2 functional area model |
| C2MOE | C2 measures of effectiveness |
| C2MOP | C2 measures of performance |
| C2NET | C2 network model |
| C2PANTHRE | control performance allied (NATO) theater, Europe model |
| C2RA | C2 Responsiveness Analysis |
| C3 | command, control, and communication |
| C3I | command, control, communication, and intelligence |
| C3ISAD | Command, Control, Communication, and Intelligence Studies and Analysis Directorate |
| CAOC | Combined Air Operations Centre |
| CDVLOC | determines unit's locations (TACWAR parameter) |
| CFE | conventional forces Europe |
| CP | command post |
| CSA | corps support area |
| CSS | combat service support |
| CSSCS | combat service support control system |
| CVBG | carrier battle group |
| DEL | delay (TACWAR run description) |
| DIV | division |
| DIVCP | division command post model |
| DOAC | Defence Operational Analysis Centre |
| DOAE | Defence Operational Analysis Establishment |
| DSA | division support area |
| EAC | echelons above corps |
| EAGLE | model used by TRAC-OAC |
| EEA | essential elements of analysis |

| | |
|---|---|
| FCVLS | sets attrition rates (TACWAR parameter) |
| FLMOE | force-level measure of effectiveness |
| | |
| hrs | hours |
| km | kilometers |
| KPIS | change in posture (TACWAR parameter) |
| | |
| LANDCENT | Land Centre (element in proposed post-CFE structure) |
| LOC | lines of communication |
| | |
| MO | TACWAR run description |
| MOE | measures of effectiveness |
| MOP | measures of performance |
| MOPO | TACWAR run description |
| | |
| NATO | North Atlantic Treaty Organizations |
| NBC | nuclear, biological, and chemical |
| | |
| OBJCTV | sets the objective for a unit (TACWAR parameter) |
| | |
| PER | personnel |
| PO | TACWAR run description |
| POL | petroleum, oil, and lubricants |
| | |
| SHAPE | Supreme Headquarters Allied Powers Europe |
| SOF | special operations forces |
| STACCS | standard Army tactical command and control system |
| SUD | truck capacity at supply distribution point (TACWAR parameter) |
| | |
| TACWAR | Tactical War (model) |
| TNGMOD | training factor (TACWAR parameter) |
| TR | technical report |
| TRAC | TRADOC Analysis Command |
| TRAC-OAC | TRADOC Analysis Command - Operational Analysis Command |
| TRAC-SC | TRAC scenario |
| TRAC-SWC | TRADOC Analysis Command - Scenarios and Wargaming Center |
| TRAC-TR | TRAC technical report |
| TRADOC | Training and Doctrine Command |
| TRU | number of trucks in support units (TACWAR parameter) |
| | |
| U.K. | United Kingdom |
| U.S. | United States |
| UMOVR | unopposed movement rates (TACWAR parameter) |
| U.S./U.K. | United States/United Kingdom |
| VIC | Vector-In-Commander (model) |

# APPENDIX D

# DISTRIBUTION LIST

## APPENDIX D

## DISTRIBUTION LIST

| Agency | No. Copies |
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| Defence Operational Analysis Centre<br>ATTN: Mr. Geoffrey Hawkins<br>Broadoaks<br>Parvis Road<br>West Byfleet<br>Weybridge KT14 6LY<br>England | 2 |
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